In Section 4 of the Office Action, the Examiner rejected claims 1, 13, and 14 under 35 USC 103(a) as being unpatentable over Simmons et al. in view of Hu. The Examiner states that Hu discloses an annealing process and it would have been obvious to one of ordinary skill in the art ... to modify the semiconductor device of Simmons to include the annealing process as disclosed in Hu because "it aids in enhancing the emissions of electrons." Applicants respectfully traverse this rejection for the reasons stated below.

Applicants believe the Examiner is incorrectly using Applicants' claimed invention as a template to combine the various elements found in the cited references. "In determining the propriety of the Patent Office case for obviousness in the first instance, it is necessary to ascertain whether or not the reference teachings would appear to be sufficient for one of ordinary skill in the relevant art having the references before him to make the proposed substitution, combination, or other modification." In re Linder, 458 F.2d 1013, 173 USPQ 560, 562 (CCPA 1972). Rather, as stated in MPEP 2141.02, the claimed invention 'as a whole' must be considered. If the insight of the inventors is contrary to the understandings and expectations of the art, the structure effectuating it would not have been obvious to those skilled in the art. Further, the prior art must be considered in its entirety, including disclosures that teach away from the claims.

The Applicants believe the Examiner is incorrect in citing Simmons as a reference. It is improper to use Simmons as a reference as Simmons does not disclose "an emitter" as Applicants are claiming. Simmons discloses a tunneling transistor device and not an emitter device and is incapable of electron or photonic emissions. Simmons discloses using resonant tunneling to create a negative resistance device. Simmons does not disclose, teach, or suggest using this negative resistance device as an emitter of electrons. Accordingly, the use of Simmons as a reference is improper and the rejection should be withdrawn.

It is also improper to combine Hu with Simmons as there is no objective reason to make this combination. One of ordinary skill would not look to Hu "to aid in enhancing the emissions of electrons" as the Examiner is asserting but rather Hu teaches using the annealing process to "maintain a sharp profile" (co1. 2, lines 35-37). Further, Hu discloses a field tip emitter (spindt emitter) and not an emitter having a "a tunneling layer disposed between the electron supply and the cathode layer" as Applicants are claiming. Therefore, Hu does not disclose the

limitation "wherein the electron supply, cathode layer, and tunneling layer have been subjected to an annealing process." Although Hu does disclose subjecting its field tip emitter to an annealing process, its purpose is to form an alloy of the silicon and the cathode layer metal to form a metal-silicide layer which helps to maintain a sharp profile(see col. 3, lines 45-60 and col. 3 line 65 – col. 4, line 4). Since the Applicants' claimed invention has the "tunneling layer" between the "electron supply" (silicon) and the cathode layer (metal), a metal-silicide layer cannot be formed nor is there a need to maintain a sharp profile. Thus, there is no motivation to use the annealing step of forming a metal-silicide layer of Hu with a tunneling emitter. Applicants' insight of annealing a flat tunneling emitter to enhance electron emission is contrary to the understanding and expectations of Hu's annealing to create metal-silicide tips that maintain their sharpness.

Further, since Simmons teaches creating a transistor and not an emitter as Applicants are claiming, there is certainly no motivation for one of ordinary skill in the art to combine the annealing step of Hu to create a metal-silicide layer with the tunneling transistor of Simmons et al. Instead it appears that the Examiner is using improper hindsight to pick limitations shown among the cited references to create Applicants' invention. Accordingly, the Examiner has failed to make a prima facie case of obviousness. Withdrawal of the rejection under 35 USC 103(a) is respectfully requested.

In the previous amendment, Applicants believe that they have demonstrated the non-obviousness of the claimed emitter and that the subjecting of the claimed emitter to an annealing process creates both statistically and significant practical results which were previously unknown to those skilled in the art and therefore not disclosed, taught, or suggested by the art made of record. Further, the Applicants have demonstrated that the physical structure of the product by process emitter is different from that of the cited art (in that the cathode layer has nanohole openings). Accordingly allowance of claim 1 is respectfully requested.

In particular for claim 13, it includes the limitation "the emitter of claim 1 disposed on the substrate" and therefore incorporates the limitations of claim 1 and is at least patentable based on the patentability of claim 1 from which it depends. Claim 13 is believed separately patentable as well.

For instance, the Examiner states that "Moyer" (not cited in the rejection) "fails to disclose" "circuitry for operating the emitter formed on the substrate with the emitter", however "Hu discloses a control device (see Figure 5)." However, Hu does not disclose that this control device is "formed on the substrate with the emitter" as Applicants are claiming. Indeed, Figure 5 shows it detached from substrate 18 which is described by Hu as a glass substrate (see col. 2, line 63 – col. 3, line 1). Applicant is unable to determine in Hu's disclosure how control circuitry would be formed in this glass substrate. According, claim 13 is believed patentable over the art made of record and withdrawal of the rejection under 35 USC 103(a) and allowance of claim 13 is respectfully requested.

In particular for claim 14, it includes the limitation "the emitter of claim 1 disposed on the substrate" and therefore incorporates the limitations of claim 1 and is at least patentable based on the patentability of claim 1 from which it depends.

In Section 5 of the Office Action, the Examiner rejected claims 2-4 under 35 USC 103(a) as being unpatentable over Simmons et al, in view of Hu and Potter. Claims 2-4 are believed patentable based at least on the patentability of claim 1 for the reasons describe above. Further, there are additional limitations which impart patentability to these dependent claims, some of which will now be discussed.

In regard to claims 2-3, the Examiner states that Simmons fails to disclose that the tunneling layer is a metal cluster dielectric, but that Potter discloses layers of alloys of titanium and tungsten and it would be obvious . . . to modify the semiconductor device of Simmons to include layers of alloys of titanium and tungsten as disclosed in Potter. Applicants respectfully traverse the Examiner's combination. Potter is directed to a "field emission" emitter device and thus does not disclose a tunneling layer nor any material that would be used for a tunneling layer. Potter discloses metal "conductive layers" and not "dielectric" layers that contact the blade edge 100 and these are not a "tunneling layer" of "metal cluster dielectrics" which Applicants are claiming. Potter uses these metal conductive layers to indeed provide good ohmic contact to the field emissive blade edge 100. Contrarily, the Applicants are sandwiching a "metal cluster dielectric," an insulator, between the cathode layer and the electron source to create a "tunneling layer" in

which electrons quantum tunnel through with sufficient energy to allow for emission of electrons from the cathode surface. Substituting the conductive layers of Potter for Applicants' "tunneling layer" would make the Applicants' invention inoperative as the electrons would not tunnel but simply conduct through Potter's conductive layers. It is the high dielectric strength of the metal cluster dielectrics which allow for high electric fields to be present without dielectric breakdown that provide the energy for the electron tunneling which creates the electron emission. Accordingly, the combination of Simmons with Potter is improper as the combination does not create Applicants' claimed invention. Accordingly, removal of the rejection under 35 USC 103(a) and allowance of claims 2-4 is respectfully requested.

In Section 6 of the Office Action, the Examiner rejected claims 5-7 under 35 USC 103(a) as being unpatentable over Simmons et al. in view of Hu and Chuman et al. The Examiner asserts that it would have been obvious ... to modify the semiconductor device of Simmons to include an emission current greater than 1×10^{-6} Amps per square centimeter as disclosed in Chuman because it aid in providing a high luminance. In addition, the Examiner states that "the applicant has not established the critical nature of the emission current of greater than 1×10^{-2} Amps per square centimeter. The Examiner further states that the "applicant must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range."

Applicants respectfully traverse the combination of Simmons and Chuman and the Examiner's assertion of obviousness. As discussed previously, Simmons is not an emitter and thus there is no motivation to increase its emissions because it doesn't have any. Nor has the Examiner reasoned or explained how the current density of Chuman can actually be increased. The claimed emission is expressed in terms of current density per area. It would not be obvious to increase the emissions of Chuman, as one could not increase the current density per area by simply making the emitter larger. The Applicants have increased the emission current density by subjecting the emitter to an annealing process that changes the structure of the emitter, thus allowing for higher emissions. Indeed, Chuman shows in its Fig. 2a maximizing of current density output of about 1×10^{-3} Amps/cm^2 by manipulating *the tunneling layer thickness*. The Applicants have

been able to far exceed this disclosed current density by at least one order of magnitude (a factor of 10X, which is both significant and unexpected by those of ordinary skill in the art) and indeed by even exceeding 3 orders of magnitude. In making the combination obvious, the Examiner does not disclose how one skilled in the art would increase the current density nor does Simmons or Chuman disclose, teach, or suggest a current density greater than 1×10^{-3} Amps/cm^2.

Further evidence of the state of the art in electron emission density is found in Kusunoki on page 1667 (bottom of left column) wherein the emission current to date (8/20/99 when manuscript received) is 50×10^{-6} Amps/cm^2. The desire for at least 1 mA/cm^2 is noted. In Fig. 5, Kusunoki only discloses an emission density of up to this 1mA/cm^2 limit, i.e. the same as Chuman.

Further, Applicant has stated in the Background of the Invention, that by increasing the current density, flat tunneling emitters can be substituted for less reliable electron field tip emitters (spindt tips), for instance:

> "conventional displays have used cold cathode devices such as spindt tips" (such as described in Hu) "to replace hot cathode technology. However , it has been difficult to reduce the size and integrate several spindt tips while maintaining reliability. As the size is reduced, the spindt tip becomes more susceptible to damage from contaminants in the vacuum that are ionized when an electron strikes it. The ionized contaminant is then attracted to the spindt tip and collides with it, thereby causing damage. To increase the life of the spindt tip, the vacuum space must have an increasingly high vacuum. A flat emitter having a larger emission surface can be operated reliably at lower vacuum requirements. However, for some applications, the amount of current density from conventional flat emitters is not high enough to be useful. Thus a need exists to create a flat emitter that has high current density that is also able to operate reliably in low vacuum environments."

The Applicants have disclosed and claimed how to increase the current density by using an annealing process. This annealing process alters the structure of the emitter by lowering the tunneling layer resistance and most importantly, creating nanohole openings in the cathode layer. It is through the application of the annealing process that these unexpected results have been obtained. An annealed emitter with a tunneling having these changes in structure have not been disclosed, taught, or suggested by the proposed combination or

other art made of record. Accordingly, the rejection under 35 USC 103(a) and allowance for claims 5-7 is respectfully requested. If the Examiner continues to assert this rejection, the Applicants respectfully request the Examiner to provide a reference or an affidavit describing how to increase the current density of Chuman.

In Section 7 of the Office Action, the Examiner rejected claims 8-12 under 35 USC 103(a) as being unpatentable over Simmons et al. in view of Hu and Liu. Applicants respectfully traverse this combination. Claims 8-12 are believed patentable based at least on the patentability of their base claim. Further, both Simmons and Liu are not "emitters" as Applicants are claiming but different versions of tunneling transistors that use tunneling not to emit electrons but rather to create negative resistance. Hu is a field emission tip emitter and does not contain a tunneling layer. Accordingly, there is no objective reason to combine these references. As such, the combination of Simmons, Hu and Liu is believed improper and the rejection under 35 USC 103(a) should be withdrawn. Allowance of claims 8-12 is respectfully requested.

In Section 8 of the Office Action, the Examiner rejected claim 15 under 35 USC 103(a) as being unpatentable over Simmons et al. in view of Hu, Xia and Gibson et al. Applicants respectfully traverse the combination of Simmons, Hu, Xia and Gibson. Claim 15 is believed patentable based at least on the patentability of claim 1 from which it indirectly depends. Further, neither Hu, Xia nor Gibson disclose an emitter having a "tunneling layer" as Applicants are claiming. Xia discloses a test device for a "field emission emitter." Gibson discloses using "field emitters" in a mass storage device. Hu discloses using "field emitters" in a display device. Simmons discloses a "tunneling layer" in a transistor device, not in a tunneling emitter. Nor is there any suggestion in Simmons, Hu, Xia, or Gibson to combine the references. Rather it appears that the Examiner is inappropriately using the Applicants' claimed invention as a template for making the combination. Accordingly, the combination of Simmons, Hu, Xia and Gibson is improper and should be withdrawn. Allowance of claim 15 is respectfully requested.

In Section 9 of the Office Action, the Examiner rejected claims 16 and 17 under 35 USC 103(a) as being unpatentable over Simmons et al. in view of Hu, and Xia. Applicants respectfully traverse this rejection. Claims 16 and 17 are believed at least patentable based on the patentability of their base claim. The Examiner states that it would obvious to modify the semiconductor device of Simmons to include a display device as disclosed in Xia because field emission is important in providing a good portable screens with good display characteristics. However, as stated previously, Simmons does not disclose a tunneling emitter but rather a transistor device that includes a tunneling layer. Hu discloses a field emission tip emitter as does Xia. Simmons' device does not create electron emissions and thus its substitution into Xia's display would make Xia inoperative for its intended purpose. Accordingly, the combination of Simmons, Hu, and Xia is improper and the rejection under 35 USC 103(a) should be withdrawn. Allowance of claims 16 and 17 is respectfully requested.

In Section 10 of the Office Action, the Examiner rejected claims 21 and 22 under 35 USC 103(a) as being unpatentable over Moyer in view of Simmons and Hu. Applicants respectfully traverse this combination. Claims 21 and 22 are believed at least patentable based on the patentability of their base claim. Moyer is directed to a field emission device and does not include a "tunneling layer" as the Examiner admits. The Examiner states that it would have been obvious to use the tunneling layer of Simmons because it aids in providing a layer for electrons to travel. As stated previously, the tunneling layer of Simmons is not used for electron emission but for creating a negative resistance layer. Even so, simply adding a tunneling layer to Moyer does not disclose Applicants' structure. Applicants have the "tunneling layer formed on the electron supply layer in the opening" and "a cathode layer formed on the tunneling layer." Forming a cathode layer on the tunneling layer would defeat the purpose of Moyer which is to create an electric field that peaks in the center of the opening (see Fig. 4 of Moyer). Applicants' cathode layer is conductive and the electric field would be substantially flat across the surface of the cathode layer. Even modifying the prior art emitter shown in Fig. 1 of Moyer would change its operation from a field emitter to a tunneling emitter which operates differently. Further, neither Moyer nor Simmons, alone or in combination, disclose, teach, or suggest "wherein the emitter has been

subjected to an annealing process to increase the supply of electrons *tunneled from the electron supply layer to the cathode layer for energy emission*." Hu discloses using an annealing process to create a silicide-metal layers as discussed previously for claim 1 to maintain the tip sharpness. Moyer discloses an emitter that does not contain a tip but rather an opening in the cathode layer. As discussed in the previous office action, Applicants' annealing step changes the structure of the emitter such that it is different (e.g. the cathode layer forms nanohole openings) from that disclosed by Moyer, Simmons, and/or Hu alone or in combination.

With respect to claim 22, Moyer does not disclose, teach, or suggest that the emitter is capable of emitting photons in addition to electron emission. Moyer instead teaches that the electron emitter emits electrons which strike cathodoluminescent material 22 which re-radiates energy as photons (col. 4, lines 17-31. Therefore, it is not the emitter that is emitting photons, as the Applicants are claiming, but a screen structure having cathodoluminescent material that emits the photons. Contrarily, because the Applicants have subjected the emitter to an annealing process that has changed the structure of the cathode surface to have nanohole structures, photons that are created by electron state transitions after tunneling are able to leave the emitter rather than being absorbed in the cathode layer as with conventional tunneling emitters.

Accordingly, removal of the rejection under 35 USC 103(a) and allowance for claims 21-22 is respectfully requested.

In Section 11 of the Office Action, the Examiner rejected claims 23 and 25 under 35 USC 103(a) as being unpatentable over Moyer in view of Simmons, Hu, and Potter. Applicants believe that claims 23 and 25 are at least patentable based on the patentability of claim 21 from which they depend. Further, as discussed previously with respect to the rejection in Section 5 of this Office Action, Potter does not disclose using a "metal cluster dielectric" as a tunneling layer but instead using metal conductive layers which simply do not function as tunneling layers. Accordingly, withdrawal of the rejection under 35 USC 103(a) and allowance for claims 23 and 25 is respectfully requested.

In Section 12 of the Office Action, the Examiner rejected claim 24 under 35 USC 103(a) as being unpatentable over Moyer in view of Simmons, Hu, and Chuman. Applicants respectfully traverse this rejection. Claim 24 is believed at least patentable based on the patentability of claim 21 from which it depends. As discussed previously for the rejection in Section 6 of this Office action, it is the annealing process that changes the structure of the emitter by creating nanohole openings in the cathode layer which allows for the higher electron density claimed by the Inventors. This annealing process is not disclosed, taught or suggested by the art made of record, including Hu. Hu discloses an annealing process that is used to create a silicide-metal layer. The Applicants' annealing process produces unexpected results which as shown provide emission current density at least one order of magnitude larger than that disclosed by previous art made of record for tunneling emitters. Such a current density allows the claimed emitter to be substituted for field emission tips (spindt) emitters. Accordingly, withdrawal of the rejection under 35 USC 103(a) and allowance of claim 24 is respectfully requested.

In Section 13 of the Office Action, the Examiner rejected claims 26 and 27 under 35 USC 103(a) as being unpatentable over Moyer in view of Simmons, Hu, and Liu. Claims 26 and 27 are believed patentable based at least on the patentability of claim 21 from which the directly or indirectly depend. Further as discussed previously in regard to section 7 of this Office Action, it is improper to combine Simmons, Hu, and Liu as none disclose an emitter with a tunneling layer as Applicants are claiming. Simmons discloses a transistor that uses a tunneling layer for a negative resistance layer. Hu discloses only a field emission tip emitter. Further, Moyer is a also a field emitter (see col. 2, lines 59-60) and also does not disclose a tunneling emitter structure, thus Moyer in combination with Simmons and Liu do not disclose, teach, or suggest Applicants claimed invention 'as a whole.' As stated previously, Applicants believe they have demonstrated significant and unexpected practical results over that found in the prior art. Accordingly, withdrawal of the rejection under 35 USC 103(a) and allowance of claims 26 and 27 is respectfully requested.

In Section 14 of the Office Action, the Examiner rejected claims 28 and 30-33 under 35 USC 103(a) as being unpatentable over Moyer in view of Simmons et al, Hu, and Xia.

In regard to claim 28, the Examiner asserts that Moyer discloses "an integrated circuit including the emitter wherein the emitter emits a visible light source." Applicants respectfully traverse this assertion. Moyer does not disclose, teach, or suggest that the emitter is capable of emitting photons in addition to electron emission. Moyer instead teaches that the electron emitter emits electrons which strike cathodoluminescent material 22 which re-radiates energy as photons (see col. 4, lines 17-31. Therefore, it is not the emitter that is emitting photons, such as the Applicants are claiming, but a screen structure having cathodoluminescent material that emits the photons. It is because the Applicants have subjected the emitter to an annealing process that the structure of the cathode surface has changed to have nanohole structures, thereby allowing photons that are created by electron state transitions after tunneling to leave the emitter rather than being absorbed in the cathode layer as with conventional tunneling emitters.

In regard to claims 30-33, the Examiner asserts that it would be obvious ... to modify the semiconductor device of Moyer to include a device for converging emissions from the emitter as disclosed in Xia because it aids in providing the luminescent display. Applicants respectfully traverse this rejection. Claims 30-33 are dependent on claim 21 and are believed at least patentable based on the patentability of claim 21.

Removal of the rejection under 35 USC 103(a) and allowance of claims 28, and 30-33 are respectfully requested.

In Section 15 of the Office Action, the Examiner rejected claim 29 under 35 USC 103(a) as being unpatentable over Moyer, in view of Simmons et al., Hu, and Gibson. Applicants respectfully traverse this rejection. Claim 29 is dependent on claim 21 and includes the limitations of claim 21. Therefore claim 29 is believed patentable based at least on the patentability of claim 21 from which it depends. Removal of the rejection under 35 USC 103(a) and allowance of claim 29 is respectfully requested.

In Section 16 of the Office Action, the Examiner rejected claims 34 and 40 under 35 USC 103(a) as being unpatentable over Moyer in view of Huang et al., Hu, and Simmons et al. Claim 34 had been amended previously to include the limitation "wherein the emitter has been subjected to an annealing process." As discussed previously, none of the art cited or made of record discloses, teaches, or suggests the Applicants' claimed invention 'as a whole,' alone or in combination. Moyer is not a tunneling emitter and adding a tunneling layer within the opening does not disclose "a cathode layer disposed on the tunneling layer and portions of the conductive layer." In fact, Moyer teaches away from Applicants' claimed structure because it discloses an emitter structure (see Fig. 4) of not having the cathode layer deposited in the opening in order to produce the non-uniform electric field. Hu discloses an annealing process to create a silicide-metal layer to maintain tip sharpness for a field emission tip emitter. A person of ordinary skill in the art by simply referring to the Moyer, Huang, Hu, and Simmons references would not be able to objectively combine the references to create the overall structure of Applicants' claimed invention in claim 34. Nor would the person of ordinary skill be able to create an emitter that emits photons as Applicants are claiming in claim 40. Moyer discloses using an emitter to emit electrons which strikes a display that has cathodoluminescent material that then converts the electrons to photons. Moyer does not disclose, teach, or suggest emitting photons as Applicants are claiming. By annealing the emitter, the structure changes, in particular the cathode layer forms nanoholes, such that photon emission and increased electron emission are possible. Accordingly, withdrawal of the rejection under 35 USC 103(a) and allowance of claims 34 and 40 is respectfully requested.

In Section 17 of the Office Action, the Examiner rejected claim 35 as being unpatentable over Moyer in view of Huang, Hu, Simmons, and Chuman. Claim 35 is deemed patentable based on the patentability of its parent, claim 34, as amended. Further, claim 35 is believed separately patentable. As discussed previously for Section 6 of this Office Action, Simmons is not an emitter and thus there is no motivation to increase its emissions because it doesn't have any. Further, the claimed emission is expressed in terms of current density per area. It would not be obvious to increase the emissions of Chuman, as one could not

increase the current density per area by simply making the emitter larger. The Applicants have increased the emission current density by subjecting the emitter to an annealing process that changes the structure of the emitter, thus allowing for higher emissions. Indeed, Chuman shows in its Fig. 2 a maximizing of current density output of about 1×10^{-3} Amps/cm^2 by manipulating the tunneling layer thickness. The Applicants have been able to far exceed this current density by at least one order of magnitude (a factor of 10X) and indeed by even exceeding 2 orders of magnitude ("about 0.1 to about 1.0 Amps/cm^2" as Applicants are claiming). In making the combination, the Examiner does not disclose how one skilled in the art would increase the current density nor does Simmons or Chuman disclose, teach, or suggest a current density greater than 1×10^{-3} Amps/cm^2. By using the annealing process and its ability to respectively alter the structure of the emitter by lowering the tunneling layer resistance, reducing ohmic contacts, and most importantly, creating nanohole openings in the cathode layer these unexpected results have been obtained. None of these changes in structure have been disclosed, taught, or suggested by the proposed combination. Further evidence of the state of the art in electron emission density is found in Kusunoki on page 1667 (bottom of left column) wherein the emission current to date (8/20/99 when manuscript received) is 50×10^{-6} Amps/cm^2. The desire for at least 1 mA/cm^2 is noted. In Fig. 5, Kusunoki only discloses an emission density of up to this 1mA/cm^2 limit, i.e. the same as Chuman. By annealing the emitter, Applicants have significantly and substantially outperformed other flat tunneling emitters created by prior art techniques thus allowing substitution for less reliable field emission tip emitters. Accordingly, the rejection under 35 USC 103(a) and allowance for claim 35 is respectfully requested.

In Section 18 of the Office Action, the Examiner rejected claim 36 under 35 USC 103(a) as being unpatentable in view of Huang, Hu, Simmons and Potter. As stated previously for Section 5 of this Office Action, Potter does not disclose, teach, or suggest where the tunneling layer is a "metal cluster dielectric" as Applicants are claiming. Further claim 36 is believed patentable based on the patentability of its parent claim, claim 34, as amended. Accordingly, the rejection under 35 USC 103(a) and allowance for claim 36 is respectfully requested.

In Section 19 of the Office Action, the Examiner rejected claims 37-39 under 35 USC 103(a) as being unpatentable over Moyer in view of Huang, Hu, Simmons and Liu. Claims 37-39 are deemed patentable based on the patentability of their parent claim 34. Accordingly, the rejection under 35 USC 103(a) and allowance for claims 37-39 is respectfully requested.

Applicants believe their claims as amended are patentable over the art of record, and that the amendments made herein are within the scope of a search properly conducted under the provisions of MPEP 904.02. Accordingly, claims 1-17 and 21-40 are deemed to be in condition for allowance, and such allowance is respectfully requested.

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